AN EXPERIMENT ON THE IMAGE SCHEMATA

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Abstract:
The main objective of this paper is to explain the process of knowledge acquisition utilising the method for the decomposition of the components of a system to extract design rules. The furnished drawing of a dwelling is considered as the language of a designer. These drawings contain the semantic knowledge that can he called general architectural know-how. This paper bases on the decomposition of the syntax of a room image. The syntax of a room image consists of walls, windows, circulation zones and furniture such as beds, wardrobes, commodes, dressing tables, etc. The syntax of a room image has some linkages. The designer put the syntax together with the joints of circulation zones as a grammar to match. The existing relations between the objects in a design can be called grammar. An experiment is applied to three classes of a CAAD course organised by the Turkish Chamber of Architects. The living room is given already furnished in the experiment and the rest of a dwelling is expected to be furnished. In the first phase, the experiment is applied on two different classes in different times. It is interesting that the same grammar is used by 6 of 8 couple of designers for 3 different types (A, B and D) of bedrooms. Only one of the bedrooms (C type) has different design styles in spite of looking much like each other. In the second phase, for the third class of 6 groups, plan is modified slightly. In this case all of the 6 couples of designers use the same grammar for 2 alternatives of D type bedroom for parents. An original method is applied in the elicitation of the knowledge in this experiment. The properties of the objects and their links are represented by a semantic network graph. This paper also presents the grammar of the furnished rooms and shows the density of preferences. Design rules are extracted from these drawings of a furnished dwelling by searching for similarities in the plans designed by different designers. The designers have some specifications about the grammar of furnishing and an image schema of the proposed room in their minds, depending on their education and experiences. During the design of a room, designers look for differences and the similarities existing in the syntax of the proposed room image and the image of furnished room on the screen. If these images match with each other, the designers satisfy with the result. This paper investigates the image schemata of the designers by evaluating their drawings. Some design rules are represented by means of image schemata. Matching the joints of circulation zones, the designers put the syntax of different image schemata together and they can illustrate different alternatives, restricted by the translation of these image schemata.

INTRODUCTION:

The main objective of this paper is to explain the process of knowledge acquisition utilising the method for the decomposition of the components of a system to extract design rules. The furnished drawings of a dwelling is considered as the language of a designer. These drawings contain the semantic knowledge that can be called general architectural know-how. This paper bases on the decomposition of the syntax of a room image. The syntax of a room image consists of walls, windows, circulation zones and furniture such as beds, wardrobes, commodes, dressing tables, etc. The syntax of a room image has some linkages. The designer put the syntax together with some kind of joints that can be called a grammar. Design rules are extracted from the drawings of the image schemata.

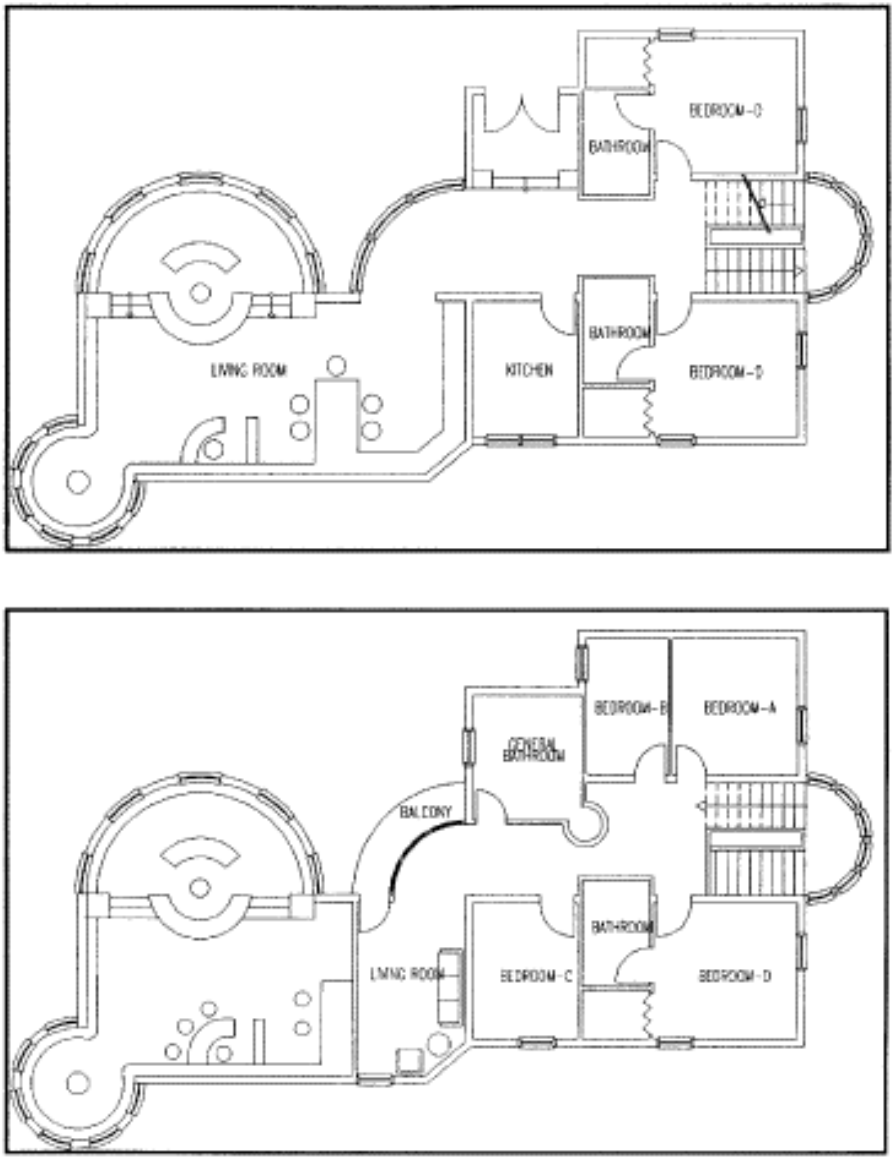
EXPERIMENT:

This experiment is applied on three classes of a CAAD course organised by the Turkish Chamber of Architects. There are 34 students who do furnishing for the same type of dwellings utilising similar kinds of symbols (as syntax) that are defined in advance by the experimenters. 15 of the designers are architects, 5 of them are graduated and 2 of them are graduate students; 15 of the them are undergraduate students in architecture and 4 of them are city planning graduate students. The graduated students have experience for 1 to 11 years in professional practice. Students' average age is 22.41 years and it is 33 years for all the CAD students.

The experiment is conducted on couples of the students. 2 Students worked on the same design task in front of a computer and utilised AutoCAD R12 for this experiment. The students are given

the symbols of the design units, that are designed to have the same size and properties for each case. The sample dwelling has two stories which has a kitchen, a hole, a bathroom and 4 bedrooms. 2 Bedrooms with bathrooms are in downstairs. Only one of the bedrooms has an independent bathroom in the upstairs. The living room is given as already furnished for this experiment and the rest of the dwelling is expected to be furnished by the students. The group of 3 bedrooms with bathrooms have the same properties. There are 4 different types of bedrooms. The location of the walls, windows and doors are asked not to be changed during the experiment.

Figure 1. THE PLANS OF THE DWELLING



In the first phase, the experiment is applied on two dissimilar classes of students in different times. At the end of this experiment, 8 groups of students in two classes complete their works. It is interesting that the same grammar is used by 6 of 8 couples of designers for 3 different types (A, B and D) of bedrooms. Only one of the bedrooms (C type) has different design style, even they seemed similar. For both A and B types of bedrooms, 3 alternatives are generated. For C type of bedrooms 4 alternatives are produced, 2 groups utilised the same grammar and the other 2 groups utilised the second one when the other 2 groups selected the third one. D type of bedrooms have

been designed with two different grammars, are repeated twice in the dwelling. One of them is a bedroom for parents and the other is a bedroom for children. 8 alternatives are created for D type of bedrooms. 6 groups use the same grammar among the 5 alternatives of D type of bedrooms for parents, when 3 of them use the same grammar in the 3 alternatives for children's bedroom.

Figure 2. THE GRAMMAR OF BEDROOM

In the second phase, for the third class of 6 groups, plan is modified slightly. An extra window is added to the A type bedroom and the size of window of the C type bedroom is two times larger than the previous one. After these alterations for both A and C type of bedrooms, each couple produce 6 different alternatives. The window of the D type of bedroom is located 100 cm. far from the previous one. This minor change influence the grammar of that bedrooms. In this case 6 of 6 couples of designers use the similar grammars for D type of bedrooms for parents for 2 alternative rooms, however, each couple use a different grammar for D type of bedrooms for the children. The window size and location do not change for B type of bedroom. 3 different alternatives are generated for B type of bedroom. 4 of 6 groups use the similar grammar in the first phase. Figure 2 and Figure 3 represents the grammar of the furnished bedrooms. Values indicate the density of preferences. The "+" sign in the pictures specify the density of preferences in the second phase. In both phases, the identical grammars for bathrooms are used by 8 of 14 groups and 5 of 14 are used another grammar, 2 of the groups select third type of grammar for the bathroom accessed from the bedroom. There are 5 alternatives for this bathroom. Depending on these findings, we understand that a bathroom has well-defined principles. It means that the designers have similar or identical image schema about the syntax of locating equipment in the bathroom. However, 6 different alternatives are produced for general bathroom. 3 of 11 groups completed general bathroom design using the same grammar, when 3 of them select the second type and 2 of them select the third type.

Figure 3. THE GRAMMAR OF BEDROOM

This may depend on the size of the bath room, because it is larger than the others. Totally, 4 alternatives for kitchen are generated. 5 of the 11 couples complete kitchen design using the same grammar and 4 of them selected another type. Figure 4 represents grammar of bathrooms and kitchens.

KNOWLEDGE ELICITATION PROCEDURE

An original method is applied in the elicitation of the knowledge in this experiment. The properties of the objects and their links are represented by a semantic network graph. This semantic network expresses the general knowledge about the furnishing of the dwelling. The "**is-a**" links express the classes and their representatives. The **"has" links** express the container schema [1]. The designers use their know-how to locate the furniture in suitable positions. The semantic network in Figure 5 corresponds to the plan.

Figure 4. THE GRAMMAR OF BATHROOMS AND KITCHENS

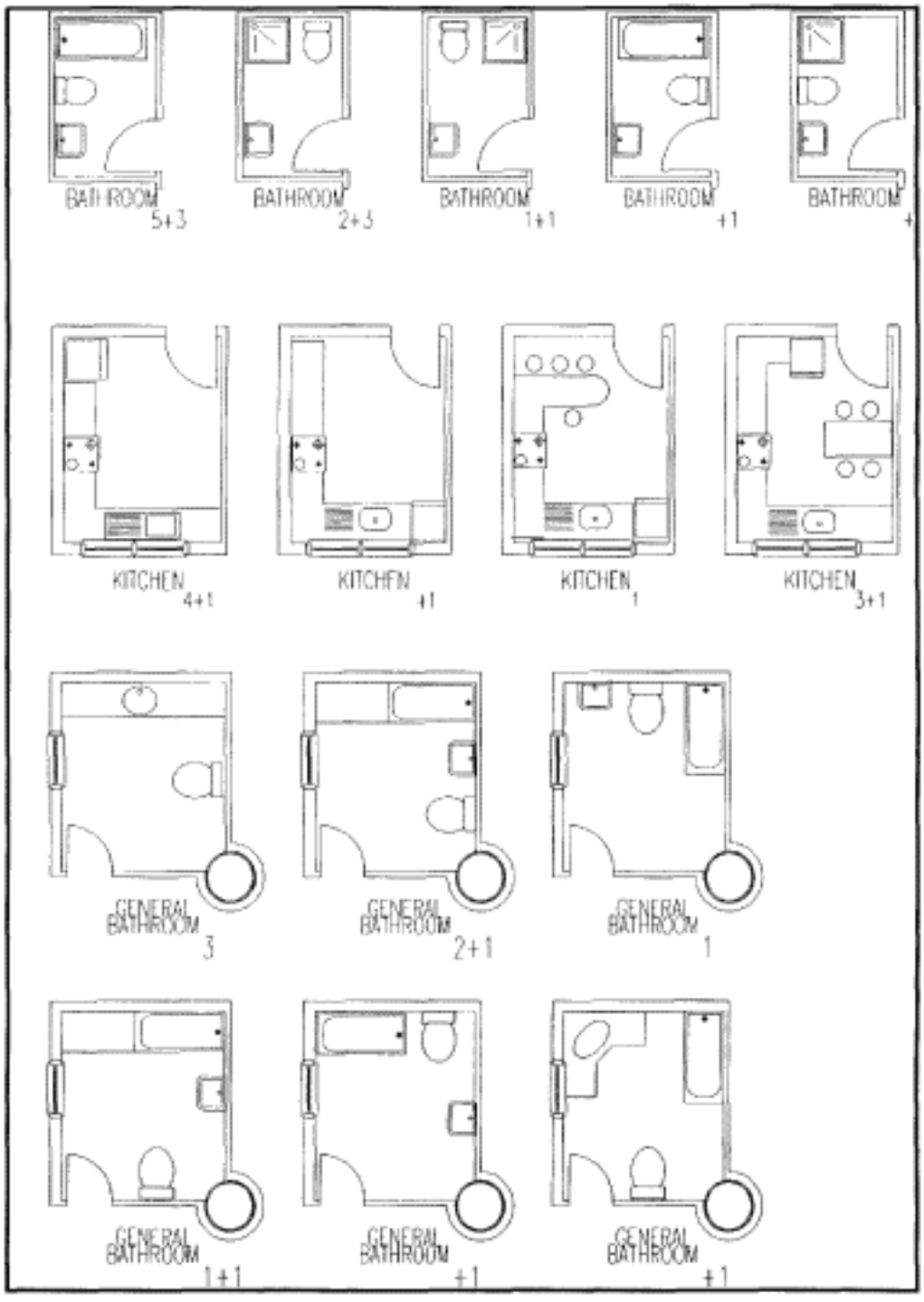
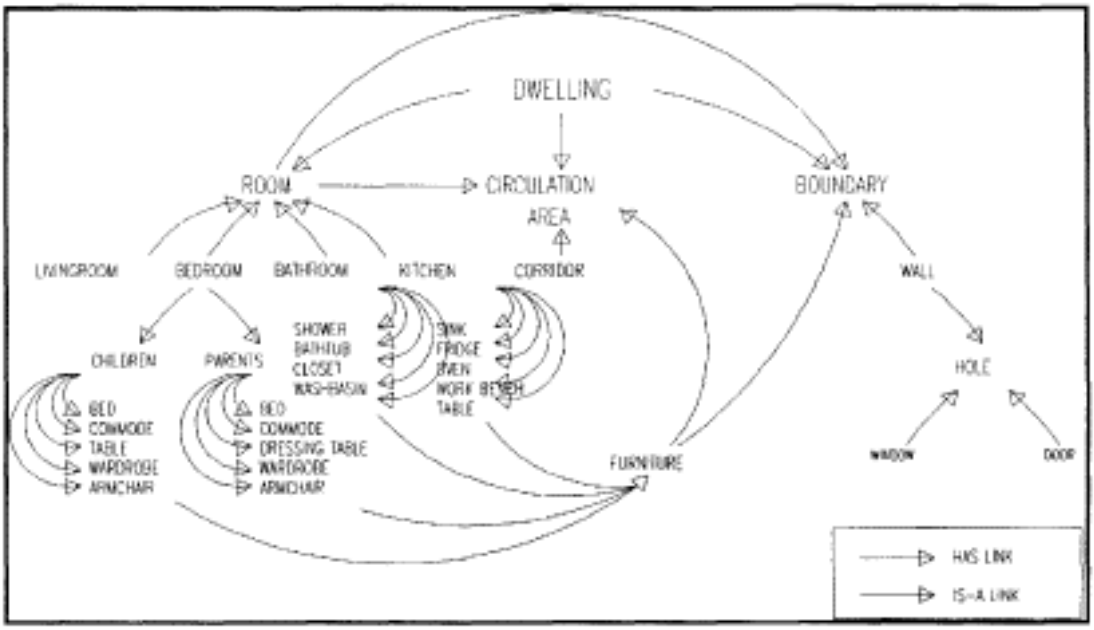


Figure 5. THE SEMANTIC NETWORK



Following sentences can be extracted from this semantic network:
DWELLING HAS A ROOM.
ROOM HAS A CIRCULATION AREA.
ROOM HAS A BOUNDARY.
WALL IS A BOUNDARY.
BEDROOM IS A ROOM.
BEDROOM HAS CHILDREN.
CHILDREN HAS A BED.
BED IS A FURNITURE.
FURNITURE HAS A CIRCULATION AREA.
FURNITURE HAS A BOUNDARY.

We can also extract the following complex meaning from these sentences:

ROOM HAS A CIRCULATION AREA AND A BOUNDARY LIKE A WALL ON THAT HAS A WINDOW AND A DOOR.

This semantic network specifies a room and its furniture have a circulation area and a boundary. The circulation area of the room is the container of a circulation area of the furniture [2]. It indicates that the boundary of a room is the container of the boundary of a furniture, If it is assumed that the furniture has a wall as a boundary, that wall should be a part of the walls of the room (its). This idea leads us to the form image schemata that have furniture with walls and circulation zones. The design rules support this idea. For example, saying *"the wardrobe should be in front of a wall and attach to a circulation zone with its front edge"* or *"the bed should attach to a wall with one edge at least'.*

The syntax of a room image consists of walls, windows, circulation zones and furniture. The components of the syntax can be classified as constants and variables. **Constants** are the boundaries of the space that hold fixed elements, such as walls, windows and doors in the problem area. **Variables** are the furniture that structure **grammar.** For example, the syntax of a bedroom image comprises furniture, such as beds, wardrobes, commodes, dressing tables, tables, armchairs, etc. and the syntax of a bathroom image comprises furniture such as shower, bath tub, lavatory, water closet, etc. In this experiment, walls, windows and doors in the image schemata of designers are also referred as variables. These are the indicatives of the designers 'know-how.

The syntax of a room image has two types of linkages. One of them is the walls in the image schemata. The walls are called as the **fixed links.** Windows and doors are the holes on the walls.

Figure 6. THE IMAGE SCHEMATA FOR BEDROOMS

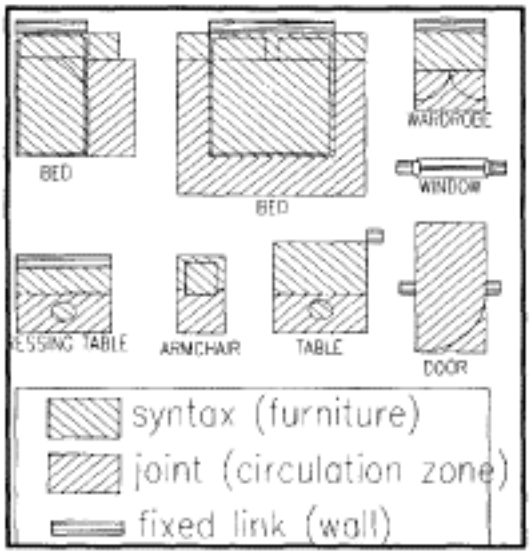
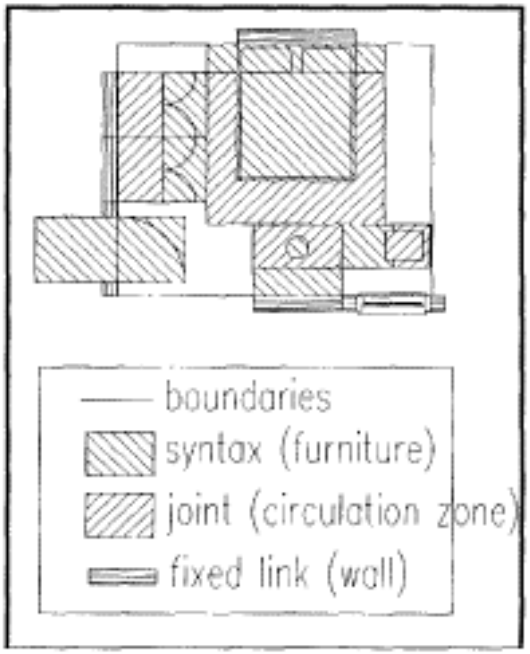


Figure 7. A GRAMMAR REPRESENTED BY IMAGE SCHEMATA



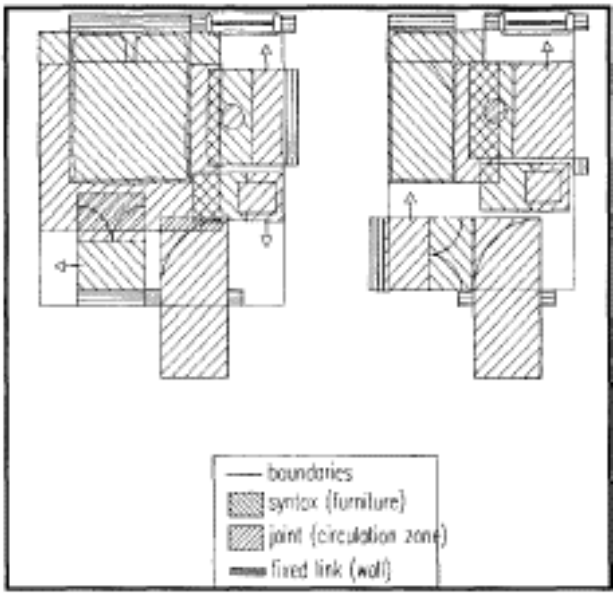
Windows are the source of light and the doors are the joints between circulation zones. The other types of linkages are the circulation zones called **joints.** Each syntax that is used for bedrooms in the experiment, is represented by the image schemata in Figure 6 and an example of a grammar can be shown in Figure 7. The joint of a syntax matches with the joint of another syntax and translates the image schemata that is an indicative of the language of a designer. Each translatic is an action firing to match the boundaries of the space with the fixed links of the image schemata and brings the design closer to a resolution. Translation is also a representation of the grammar of a designer that is used by him or her at that time, the designer always compares the boundaries of the space with the fixed links of the image schemata. Fixed links can be located anywhere on the boundaries. Figure 8 represents the translation of the image schemata.

Matching the joints of circulation zones, the designers put the syntax of different image schemata together and they can illustrate different alternatives limited by the translation of these image schemata to anywhere. The joints of circulation zones in a syntax can move on, turn around or match on to another joint. At the same time, it can be expanded, but it can not be tightened, because the defined syntax has the minimum size of the joint.

Designers have some specifications related to the grammar of furnishing and an image schema of the proposed room in their minds depending on their education and experiences. During the design of a room, the designer looks for differences and the similarities existing in the syntax of the proposed room image and the image of furnished room on the screen. If the proposed room image and image of furnished room match with each other, the designers satisfy with the result.

We said that the designer put the syntax together with the joints of circulation zones as a grammar. We aimed at illustrating the idea of evaluating a type of design syntax that is preferred by a number of designers, instead of that is preferred by only one designer. Similar experiments are realised by the other authors that are based on a cognitive model of a number of designers, those can explain their own domain knowledge in that field. Design rules are extracted from these drawings of a furnished dwelling by searching for similarities in the plans designed by different designers. In the second phase of this experiment, designers write their design procedures step by step. The rules and also the behaviour graphs of designers are extracted from these written documents. Written procedures verify the image schemata.

Figure 8. THE TRANSLATION OF THE IMAGE SCHEMATA



According to design procedures, in the furnishing of bedrooms, designer locates bed in front of a wall at the beginning of the design. Then commodes are located near the bed and wardrobe is located on one of the corners of the boundaries. If it is a bedroom for parents, wall is reserved for dressing table. If it is a bedroom for children, a table is located near or in front of the window. In the bathroom, the shower or bathtub is located on the corner at first. Water closet follows it and then the washbasin is located. However, the location of washbasin and closet have already been known. Their locations are reserved at the beginning. These procedures indicate that equipment has such relations with walls, windows and doors that each syntax has its own wall, window or door on the image schemata.

CONCLUSIONS:

The importance of image schemata as a method of knowledge acquisition should be investigated from expert systems' point of view. Foundations of this experiment can be used for building an expert system to furnish a dwelling plan. The method developed related to image schemata, introduces a facility for displaying the design rules in designers' mind. If they are analysed in detail, domain knowledge in a specified field can be acquired. The image schemata has important impact on cognitive structures of designers for computerised learning and teaching in computer aided architectural design. It is a very difficult procedure to acquire knowledge and to understand cognitive structures of the designers by conversations. Conversations require to define concepts. In this experiment, it is understood that designers prefer visual communication, even in written documents. Development of a kind of shell to understand the image schemata and to learn rules from it will be useful for computer aided architectural design. The proposed method can be used to develop such a shell to assist designers.

References:

[1] Lakoff G., Cognitive Semantics, Institute of Cognitive Studies, University of California at Berkeley, March 1986.

[2] Bayazit M, Development of a Knowledge Acquisition Model for Computer Aided Design, International Conference on Engineering Design, ICED, Dubrovnik, 28-31 August 1990